



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105-2498

OFFICE OF
AIR AND RADIATION

MARCH 14, 2000

Dear Manufacturer:

CCD-2000-01 (LDV/LDT/MC/SM/LIMO/HD)

SUBJECT: Revision in CVS Verification Procedure

SUMMARY

EPA is revising the procedure used in its laboratories for CVS verifications. Over the next few weeks, EPA will begin using a density of 52.82 g/ft³ for calculating the mass of propane injected into the sampling system using a critical flow orifice injection device. This density reflects propane's non-ideal behavior in a pure state when metered by a critical flow orifice. This density is approximately 1.8% greater than predicted by the ideal gas laws. For calculating the mass of propane recovered as measured in a dilute sample stream EPA will use the density value of 51.90 g/ft³.

BACKGROUND

CVS verification is the process where a known quantity of tracer gas is released into the sampling system instead of vehicle exhaust. The "exhaust" sample is then analyzed and the amount of tracer gas recovered is determined. The amount recovered is compared to that which was released; if it is within $\pm 2\%$ the system is acceptable for use. If not, then corrective action is required.

During the early years of CVS testing, verifications were performed using a small cylinder of propane. This cylinder was weighed both before and after the verification, the difference being the amount released. This method is referred to as the "gravimetric" technique in the regulations. (Because this gravimetric procedure directly measures the mass of propane used, it is not effected by the non-ideal behavior addressed in this letter.)

While it is conceptually simple, the gravimetric technique requires a relatively heavy cylinder to contain a small amount of propane. This heavy mass compromises its accuracy. The regulations allow use of a critical flow orifice (CFO) to meter propane; this is the technique currently used by EPA and many manufacturers. The CFO technique employs a small orifice to pass propane at the speed of sound (critical flow). By knowing or measuring several items (flow calibration of the orifice, duration of propane flow, temperature and density of propane), the mass of propane released can be calculated.



Printed on Recycled Paper

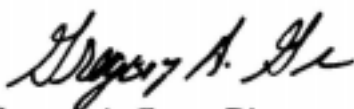
When the CFO technique was implemented, it was assumed that pure propane obeyed ideal gas laws. While that assumption is appropriate for a dilute sample, (such as simulated vehicle exhaust), it is not true when pure propane passes through the CFO. Because propane metered by a CFO has a density approximately 1.8% higher than predicted for an ideal gas, there is significant potential that a properly functioning sampling system would exceed the 2% verification tolerance. The discrepancy between ideal and actual properties became an issue as EPA and vehicle manufacturers began installing improved sampling equipment required to test lower emission vehicles. This equipment is more accurate and has reduced variability. As a result the discrepancies in the propane densities have become more apparent. EPA is in the process of revising its laboratory practice to use the actual density. Manufacturers using the CFO technique should review their procedures and take appropriate action.

CVS verification is not a primary calibration. It is merely an independent check of the sampling and hydrocarbon analytical systems. Since no change is being made in the way these systems are calibrated, test results will not be effected. Using the correct propane density simply restores equivalency between the gravimetric and CFO techniques. This equivalency was intended when the CFO procedure was developed.

(The specific details of EPA's change are as follows: Instead of assuming an "ideal" density of 51.90 g/ft³, the quantity of propane metered by the CFO will be calculated using 52.82 g/ft³. Densities are referenced to the 760 mm Hg, 20 C "standard" used in EPA's regulations. Manufacturers must use appropriate adjustments for their equipment and calibration methods. Please note that the densities for dilute propane and exhaust hydrocarbon, *expressed on a per carbon atom basis*, have not changed; propane is an ideal gas under dilute conditions. Exhaust and propane have slightly different densities; this occurs because exhaust hydrocarbon is assumed to have an average formula of C₃H_{5.3}; propane is C₃H₈.)

If you have any questions on the technical matters addressed in this letter please direct them to Carl Ryan, Laboratory Operations Division, (734) 214-4251, ryan.carl@epa.gov.

Sincerely,



Gregory A. Green, Director
Certification and Compliance Division
Office of Transportation and Air Quality